8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

Measurement of Adsorbate Properties with the Pull-in method

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Key Words: *Adsorption, Pull-in method, nanostructures, multilayer cantilever, GDQ.*

ABSTRACT

This paper proposes a model for extracting mechanical properties of adsorbate layers on the upper and lower surface of micro and nano devices. Molecular adsorption on a micro and nano cantilever surface changes the pull-in behavior of cantilevers as a result of adsorption-induced stress and stiffness. Without understanding the adsorbate properties it will be almost impossible to develop accurate and stable mechanical structures with submicron dimensions. The proposed model is based on a nonlinear multilayered cantilever beam model. Due to the complexity of the nonlinear beam mechanics, exact analytical solutions are not generally available; therefore, the derived nonlinear equation has been numerically solved using Generalized differential quadrature method (GDQM).

MAIN RESULTS

For two cantilever materials and two organic and biological adsorbed layers we show the efficiency of our model. As cantilever materials we have chosen silicon(ρ_1=2330 Kg/m^3, E_1=169 GPa) and the photoresist SU-8(ρ_1=1190 Kg/m^3, E_1=4.0 GPa)[1]. As paradigmatic organic and biological layers on the cantilever, we have chosen the self-assembeled monolayer (SAM) formed by the alkanethiol $-SH-(CH_2)_{11}-CH_3$ (ρ_2=675 Kg/m^3, E_2=12.9 GPa) and the monolayer formed by the myosin subfragment 1 (ρ_2=183 Kg/m^3, E_2=0.7 GPa). The mechanical properties of these films were previously obtained from monolayers with a thickness of few nanometers via forced-based techniques[2,3].Fig. 1(a) shows pull-in voltage versus the ratio between the thickness of the uniformly adsorbed layers of SAM and protein and the Silicon cantilever. Fig. 1(b)is demonstrated for SU8 cantilever which adsorbed SAM and Protein. it is clear that this method is highly sensitive for stiff materails like SAM. Fig. 2 shows the deflection of cantilever after adsorbtion and during applying voltage.

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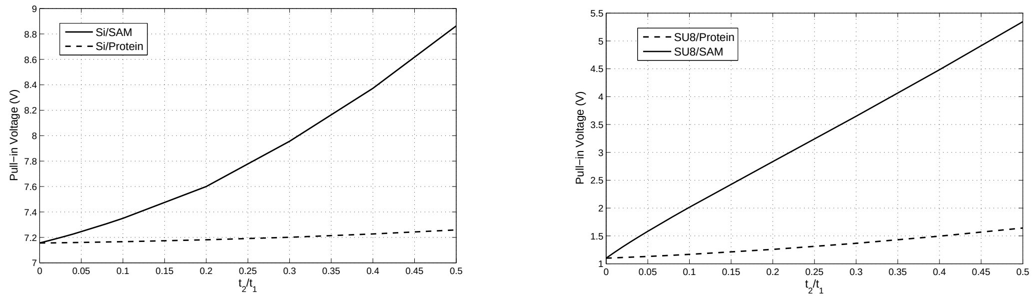

(a) Pull-in voltage for silicon cantilever (b) Pull-in voltage for SU8 cantilever

Figure 1: Pull-in voltage vs. ratio between the thicknesses of the uniformly adsorbed layers and the cantilever

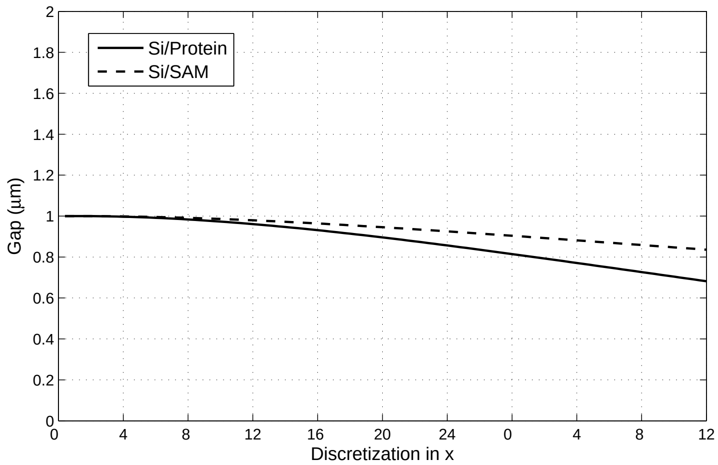

Figure 2: Deflection responses of Si cantilever with SAM and Protein adsorbed layer.